Computer Graphic Animation Tools for Robotics

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Computer graphics are being applied in an increasingly large number of application areas. Long used in Computer Aided Design, graphics is now being widely used in business, scientific, and manufacturing. This trend is likely to continue as graphic hardware technology improves and novel applications are developed.

Graphics hardware performance has a significant and perhaps decisive impact on the nature of the man-machine interface that is possible. Because there are several performance parameters, applications can become hardware specific even if the software is portable. Vector storage terminals which adequately support two dimensional drafting packages quickly become unsuitable for applications with a higher man-machine bandwidth, such as solids. This paper reports on the use of computer graphic animation in a rather narrow application area: robotics.

Robots are jointed machines used to move materials and tools, typically in manufacturing operations. They are usually classified as a form of flexible automation because they are programmable. Robots also imply a degree of complexity, so that mechanically simple devices and forms of hard automation are normally not included.

One of the major problems in robotic applications is understanding the motions that a particular robot is capable of attaining. The end-effector of a robot can be aligned in any subset of the six degrees of freedom possible. When one examines the typical specification for a particular robot, the implication is made that the robot can achieve any combination of the six degrees of freedom within this space. For some cartesian coordinate system robots, this may be true, but generally there are regions within this space that either the robot cannot attain some orientation and/or roll or cannot reach at all. Variations in the end-effector geometry complicates the situation. It is impossible beforehand to intuitively anticipate where these problems will occur and difficult and expensive to deal with during the installation of a robot. This problem also occurs during the programming of the robot in an environment where its task can change. As a result, robots are rarely used in applications where their task changes to a significant degree and instead frequently become a form of fixed automation.

McDonnell Douglas Automation Company has for the last few years been developing and testing and has recently announced as a product a software package used for designing robot applications. This package, called PLACE, uses kinematic models of various robots and displays them to the user in an animated fashion. Animation has proved to be a very desireable capability. The user can see the robot at each intermediate position which much more closely reflects the activities taking place on the shop floor. As a result, the user can understand the events occurring with much less effort than would be required if the display consisted of static snapshots of different intervals. If the intervals are too widely spaced, the intervening conditions are obscured, while closely spaced intervals result in a lengthy and tedious man-machine interaction.

The use of graphic animation results in the need for a high bandwidth for rapid update. This puts certain forms of simulation impractical at the present time. For instance, collision detection would be a useful form of feedback to the user. However, the calculation necessary to check all the various intermediate configurations of the robot is not possible in the time constraints imposed by animation. On the other hand, by using the capability of the display to show animation, the user can manually detect collisions by using his knowledge of the current state of the robot and by changing the view of the robot in its environment.

A second graphic animation tool developed at McDonnell Douglas is a robot program simulator called ANIMATE. This package was developed to assist in the verification and debugging of robot offline programs written in Manufacturing Control Language (MCL). MCL was developed at McDonnell Douglas under the United States Air Force Integrated Computer Aided Manufacturing (ICAM) Program in 1980. The output of the MCL processor is an enhanced form of CLDATA, which is a data format commonly used in Numerical Control (NC) machines. ANIMATE also includes kinematic models of the various devices in a robotic application and provides a display which resembles that of PLACE. However, instead of receiving instructions from the user as in PLACE, ANIMATE interprets the input CLDATA file. It also references a set of data generated by PLACE which includes the descriptions and relationships of the various devices in the robotic application.

Experience to date has shown that tools such as these can be extremely powerful and useful. Ongoing tests of PLACE and ANIMATE in application environments have shown them to be highly productive. As more is learned about how people can take advantage of animation, significant improvements over the existing technology is expected.

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